ICHTHYOLOGY.—*A study of the luminous organ of the apogonid fish* Siphamia versicolor (*Smith and Radcliffe*). TAMOTSU IWAI, Kyoto University, Maizuru, Japan. (Communicated by Ernest A. Lachner.)

(Received June 27, 1958)

The luminous organs of fish have received much attention and have been reviewed comprehensively by Harvey (1957, p. 345). Despite the fact that the luminous behavior of large numbers of both elasmobranch and teleostean species has been reported, the data available on the luminous organs of apogonid fishes are sparse and inadequate. The first information on a luminous apogonid was made by Kato (1947, p. 195). He found that *Apogon marginatus* Jordan and Snyder possesses three organs on the bend of the intestine and on either side of the rectum immediately before the anus. Iwai and Asano (1958, in press) found similar luminous organs on *Apogon ellioti* Day, and concluded that the nominal species *A. marginatus* is identical with and predated by *A. ellioti*. This was the only species of apogonid known to possess luminous organs until the silvery gland of *Siphamia* was suspected.

Siphamia, a genus of the family Apogonidae, is characterized by having a silvery gland extending from the isthmus to the lower corner of the caudal peduncle along the ventral contour of the body (Weber and de Beaufort, 1929, p. 356; Schultz, 1940, p. 404; Lachner, 1953, p. 413). The general appearance of this gland resembles the luminous organs found in certain other fish, e.g. *Paratrachichthys prosthemius* Jordan and Fowler, but no attempt has been made to clarify the function of this remarkable structure. Knowledge of whether this structure has relation to luminescence is desirable, for such information would give us a better understanding of the relationships and classification of the luminous apogonids with other members of the family. The author had the privilege of examining some specimens of *Siphamia versicolor* (Smith and Radcliffe) through the courtesy of Dr. Ernest A. Lachner of the United States National Museum. The present communication consists of observations on this material.

The author is indebted to Prof. Kiyomatsu Matsubara, under whose direction the present work was undertaken. Grateful acknowledgment is made to Dr. Ernest A. Lachner for his critical reading of the manuscript.

The study material consisted of three specimens, U.S.N.M. no. 112269, measuring 20.0–24.5 mm in standard length. These were collected from Cataingan Bay, Masbate, Philippines, on April 18, 1908, by the *Albatross* Expedition. Of these one specimen was dissected and the lower portion of the body was serially sectioned by the usual paraffin method at a standard thickness of 10 micra. The serials were stained with Mayer's hemalum and eosin.

For comparison, one specimen of the luminous berycoid, *Paratrachichthys prosthemius* Jordan and Fowler, which has a subcutaneous striated band along the lower surface of the body somewhat like *S. versicolor*, was also sectioned.

All drawings were made by camera lucida tracing, although the detailed structures were diagrammatized.

RESULTS

Siphamia versicolor is a small species attaining a standard length of approximately 30 mm and appears to be an endemic form to the Philippine Archipelago. The body is deep and compressed, the ratio of depth and width to the standard length being 2.1–2.4 and 4.6–5.4, respectively. The head is remarkably large, its ratio to the standard length being 2.1–2.5. The ground color in alcohol is dusky silver with three longitudinal brown stripes. The uppermost stripe begins on the tip of the snout and runs posteriorly along the dorsal contour of the body to the caudal peduncle. The second one extends from the tip of the snout through the eye to the caudal base. The lowermost one originates on the upper edge of the maxillary and extends backwards passing through the pectoral base to the ventral corner of the caudal pe-

duncle. Along the ventral border of the third stripe a curious silvery band lies between the isthmus and the caudal peduncle.

On the ventral aspect the band originates on either side of the brownish midline-keel of the isthmus, and extends and expands on each side posteriorly to the base of the ventral fin. At this level the band is greatest in width: it occupies a wide area between the lower edge of the pectoral base and the midline of the belly. From there it extends posteriorly in parallel branches, one on each side, and each tapers gradually to the rear at the ventroposterior corner of the caudal peduncle (Fig. 1).

Histological examination revealed that this band is the longitudinal muscle bundles lying just beneath the dermis. They are sheathed with an extraordinarily developed epimysium which is composed of opaque fibrous connective tissue (Fig. 2, A, B, C, *mb* and *fs*). The microscopic feature of this sheath is essentially the same as the reflector-like structure mentioned below. Externally, the muscle bundles are lined with thin layers of the dermis and epidermis enclosing the imbricated scales.

Structural evidence of these muscle bundles is quite similar to that of *Paratrachichthys prosthemius*, though the epimysium of the latter species is more densely dotted with melanophores. In his work on the luminous organ of *P. prosthemius*, Haneda (1957, p. 18) gave the name "filiform body" to the muscle bundles lying posterior to the base of the ventral fin and "keel muscle" to those lying anterior to the ventral base. He concluded that these structures take charge of diffusion of the light emitted from the luminous organ.

Within the body wall and immediately before the base of the ventral fin, there extends a curious organ which is composed of three distinct elements. The striking and perhaps most functional element is a compact mass of polyhedral cells lying in the middle layer of the organ. The mass itself is small, bean-like in shape (Fig. 1, *lo*). It measures 2.0 mm in length, 1.4 mm in width, and 0.25 mm in thickness in a specimen measuring 24.0 mm in standard length. The cells, forming the mass, are somewhat long and polyhedral and are packed together, not arranged in a row. The cytoplasm of each cell is filled with granular secretion stained deeply by eosin. The blood supply is evidently connected with the base of the mass.

Dorsally, the main structure mentioned above is wholly covered by an opaque stratum of fibrous connective tissue (Fig. 2, *rf*). This layer is comparatively thick, it being as thick as the mass structure, and occasionally dotted with melanophores. Its dorsal surface is exposed to the abdominal cavity and it is recognized as a white marking. This structure is virtually the same as the reflector of the luminous organ of *Apogon ellioti* (Iwai and Asano, in press). The fact that this layer covers the proximal edge of the organ like a cap would lead one to suppose that it may act as a reflector of light as is the case with the luminous organs of some fishes.

The third element, a well-defined, thick layer, is composed of a pair of longitudinal muscle bundles, and is located on the ventral side of the main structure. The cross section of these bundles is roughly elliptical in shape (Fig. 2, *le*). The arrangement and general feature of these muscle

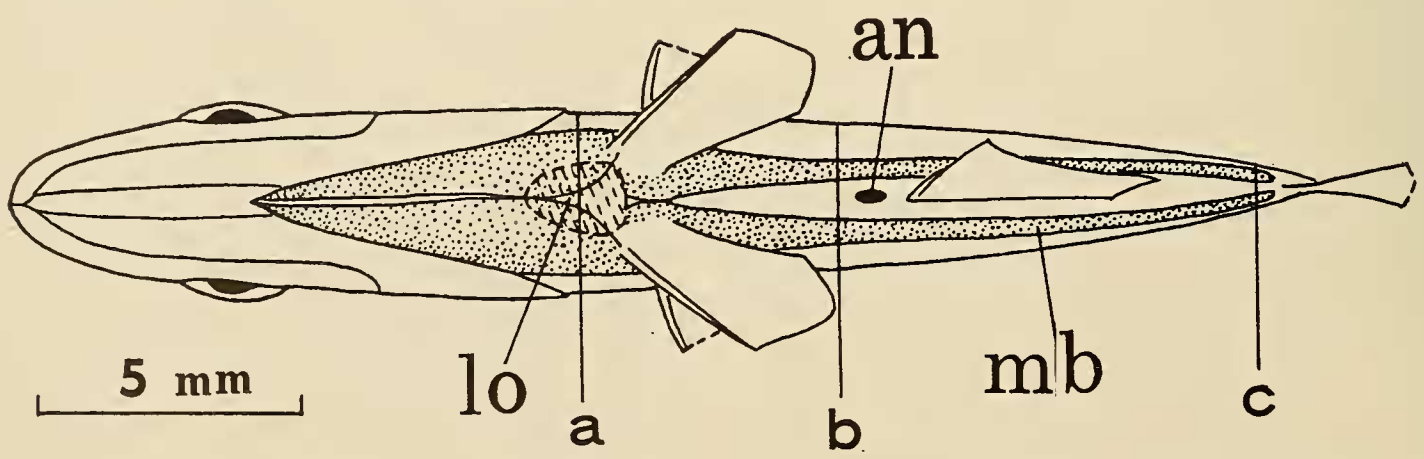

FIG. 1.—Ventral aspect of *Siphamia versicolor*, showing longitudinal muscle bundles (*mb*) and position of luminous organ (*lo*); *an*, anus.

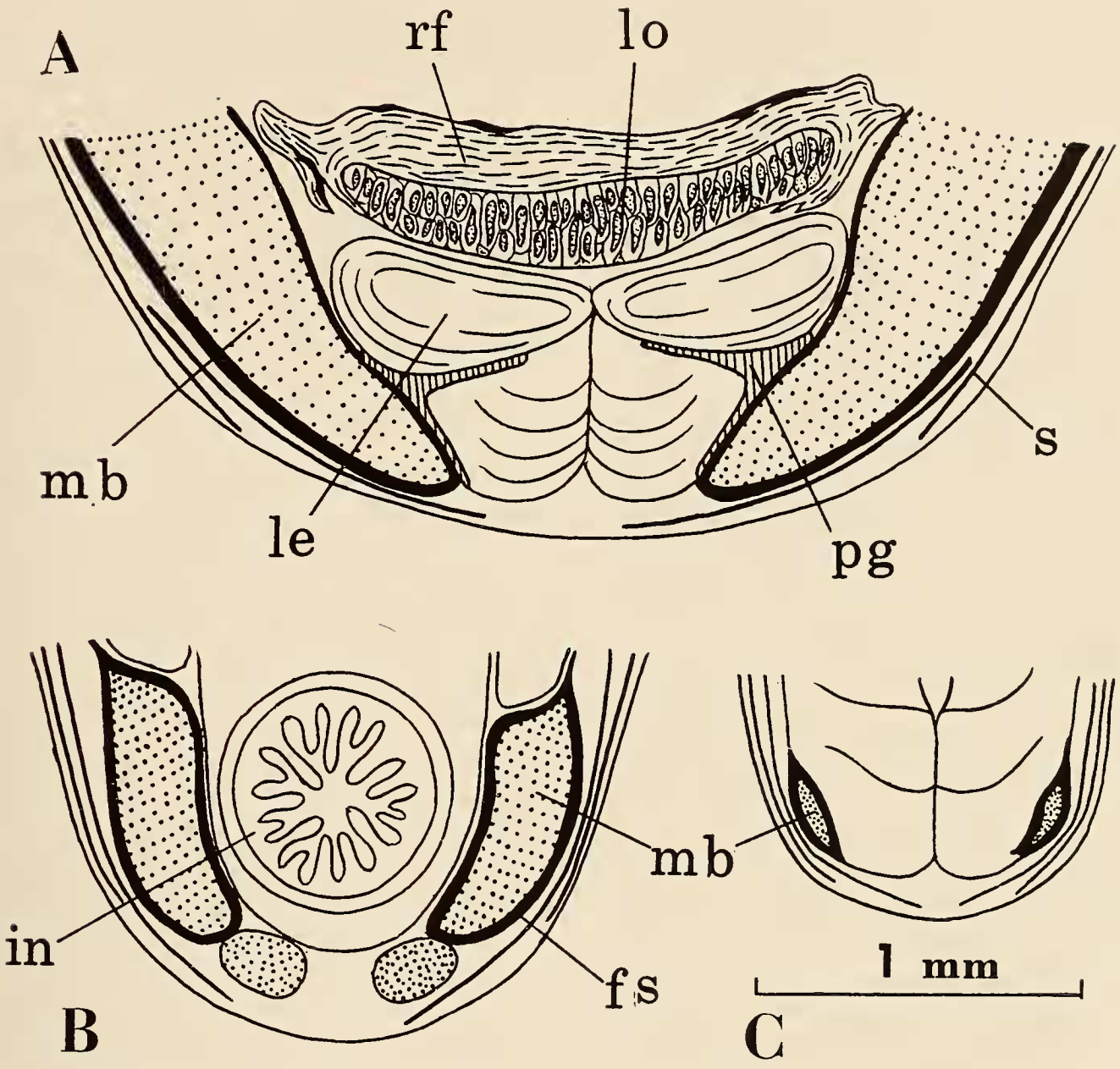

FIG. 2.—Transverse sections of lower portion of the body of *Siphamia versicolor* at levels indicated in Fig. 1 as a, b, and c.: *fs*, fibrous sheath; *in*, intestine; *le*, lens; *lo*, luminous organ; *mb*, longitudinal muscle bundle; *pg*, pelvic girdle; *rf*, reflector; *s*, scale.

bundles resemble the lens of the luminous organ of *Acropoma japonicum* noted by Haneda (1950, p. 218). The pelvic girdle is inserted between these muscle bundles and the aforementioned keel muscle.

In evaluating the results of the dissection, it seems highly probable that the mass structure of polyhedral cells lying above the pelvic girdle would be a luminous organ (Fig. 2, *lo*). Neither an opening to outside of the body nor a connection to the alimentary canal is present in this luminous organ. Photogenesis of this species, therefore, appears to be intracellular. The polyhedral cells with a granular secretion would be photogenic cells.

DISCUSSION

No definite decision in regard to the function of the curious organ in *Siphamia versicolor* is tenable, since no physiological result is available. However, it may be of value to provide a brief outline of suggestive evidence obtained by the microscopic anatomy. This may form a basis for interpreting the possible function of this organ. Insofar as it was observed, the mass structure bears, like the luminous organs of some other fishes, peculiar accessory structures such as: (1) a reflectorlike structure of fibrous connective tissue, (2) longitudinal muscle bundles which may serve as a lens, and (3) longitudinal muscle bundles with fibrous sheath lying along the ventral contour of the body. These structures as well as the position of the mass structure in the abdominal body wall, imply the possibility of the luminous function of this organ. Haneda (1957, p. 19), in making observations with living material of *P. prosthemius*, reported that by means of mechanical stimulation of the luminous organ situated near the anus, the luminescence occurs along the keel muscle and the filiform body. The latter two structures are equivalent to the longitudinal muscle bundles lying on the ventral margin of the body of *Siphamia*. This supports further the above mentioned postulation.

Lachner (1953, p. 413) wrote that the

subcutaneous glands form a hollow canal. This study indicates that these are longitudinal muscle bundles covered by the stratum of fibrous connective tissue.

There is an urgent need for examination of living specimens assigned to *Siphamia* in order to confirm their luminescence. This structure is sufficiently distinct to characterize the genus *Siphamia*, as was pointed out by various authors.

Fowler (1938, p. 40) proposed a new subgeneric name, *Aulotrachichthys,* for the deep-sea berycoids, *Paratrachichthys latus,* and *P. prosthemius,* based on the subcutaneous striated tubes of the lower body surface. Haneda (1957, p. 19) pointed out that these tubes consist of the muscle bundles and serve as an accessory structure of the luminous organ.

The luminous organ of *S. versicolor* agrees in both its position at the thoracic region and the accessory muscles bundles with that of *P. prosthemius,* but it is probably neither homologous nor analogous with that of the latter species. The fundamental differences between them are exemplified in other structures. The luminous organ of *Siphamia* consists of a compact mass of polyhedral cells with granular cytoplasm and lacks openings to the outside of the body or to the alimentary canal, whereas the organ of *Paratrachichthys* comprises ramified ducts surrounding the anus and has openings to the exterior. Photogenesis appears to be intracellular in the former species in contrast to the luminous bacteria of the latter species.

The luminous organ of *S. versicolor* also differs from that of the luminous apogonid, *Apogon ellioti.* The latter species possesses three luminous bodies composed of columnar cells with eosinophil secretions located on the second bend of the intestine and on either side of the rectum immediately before the anus. Each opens into the intestine (Kato: 1947, p. 195; Iwai and Asano: 1958, in press).

In view of the marked peculiarity shown in the luminous organ, it is conceivable that not only the differentiation of the muscle bundles but also other structural evidence of the luminous organ are enough to substantiate the generic position of *Siphamia.*

SUMMARY

1. *Siphamia versicolor* (Smith and Radcliffe) possesses a curious organ within the body wall immediately before the base of the ventral fin, which is probably luminescent.

2. The organ is lined dorsally with a structure like a reflector and ventrally with a structure like a lens. Photogenesis appears to be intracellular.

3. The silvery gland lying along the ventral contour of the body is composed of longitudinal muscle bundles sheathed with a fine stratum of fibrous connective tissue. This may act as an important element to diffuse the light emitted from the luminous organ.

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